Bonneville Power Administration
Fish and Wildlife Program FY99 Proposal Form

Section 1. General administrative information

Survival Estimates for the Passage of Juvenile Salmonids Through Dams and Reservoirs

Bonneville project number, if an ongoing project 9302900

Business name of agency, institution or organization requesting funding
National Marine Fisheries Service

Business acronym (if appropriate) NMFS/NWFSC

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Subcontractors. List one subcontractor per row; to add more rows, press Alt-Insert from within this table

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NPPC Program Measure Number(s) which this project addresses.
5.0F, 5.8A.8

NMFS Biological Opinion Number(s) which this project addresses.

NMFS BO RPA Sec. 13f

Other planning document references.

If the project type is "Watershed" (see Section 2), reference any demonstrable support from affected agencies, tribes, local watershed groups, and public and/or private landowners, and cite available documentation.

NMFS RP 2.1.d.3.

Subbasin.

Short description.

Provide precise measurements of survival of juvenile salmon as they pass through dams and reservoirs in the Snake and Columbia Rivers

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
X	Anadromous fish		Construction		Watershed
	Resident fish		O & M		Biodiversity/genetics
	Wildlife		Production		Population dynamics
	Oceans/estuaries	X	Research		Ecosystems
	Climate	+	Monitoring/eval.	X	Flow/survival
	Other		Resource mgmt		Fish disease
			Planning/admin.		Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.

Juvenile salmonid passage survival

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
91-029	Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River Basin	We began working cooperatively with this project in 1995 to estimate survival for hatchery-reared and wild subyearling fall chinook salmon through free-flowing sections, reservoirs, and dams of the Snake River.
96-006	PATH	Our study provides critical and empirical data used for modeling survival through the hydrosystem in PATH.
83-319	New fish tag system	We continue to rely on this project to provide the innovations needed to

		conduct multiple-recapture survival studies in the Snake and Columbia Rivers. We provide feedback to this project on the performance of many of their innovations.
94-034	Assessing summer/fall chinook restoration in the Snake River Basin	We began working cooperatively with this project in 1996 to estimate survival for hatchery-reared subyearling fall chinook salmon released in the Clearwater River.
83-323	Smolt condition and arrival timing at Lower Granite Dam	We estimate survival for PIT-tagged fish released from Snake River Basin traps in this study through the Snake River.
96-020	Comparative survival rate study of hatchery PIT tagged chinook	We utilize fish PIT-tagged from this study to estimate survival from hatcheries through the Snake River.

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Provide annual estimates of survival for spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs	a	PIT-tag and release juvenile salmonids at Lower Granite Dam.
		b	Estimate detection and survival probabilities (with standard errors) for above releases.
		c	Estimate survival for PIT-tagged fish released in other studies in the basin (hatcheries, traps, etc.).
2	Estimate survival through longer reaches of the Snake and Columbia Rivers	a	Evaluate post-detection bypass survival at new PIT tag facilities.
		b	Determine effects of new PIT tag interrogation facilities on sample size requirements for PIT tag studies conducted upstream.
3	Partition mortality between release at hatcheries and the head of Lower Granite Reservoir	a	Release PIT-tagged/radio tagged (combination tag) fish from a Snake River Basin hatchery to determine where mortality and migrational delay occur.

		b	If results from Task a warrant, in future years, capture, PIT-tag, and release smolts from areas where losses or excessive migrational delay occur.
4	Estimate survival of subyearling fall chinook salmon migrating through the Snake River	a	Release PIT-tagged Lyons Ferry Hatchery subyearling fall chinook salmon into the free-flowing Snake and Clearwater Rivers.
		b	Estimate their survival and compare to estimates of survival for wild migrants in this reach.
5	Explore relationships between smolt survival through the Snake and Columbia Rivers and flow, travel time, and dam operations using a long-term data set	a	Correlate survival estimates with flow, temperature, travel time, and dam operations for individual years and over multiple years.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	03/1993	12/2015	14
2	03/1994	12/2015	12
3	03/1996	12/2001	45
4	05/1995	12/2015	26
5	03/1993	12/2015	3

Schedule constraints.

1. Delays in installation of PIT tag interrogation systems at additional dams would limit our ability to estimate survival through additional reaches.
2. Availability of fish for PIT-tagging because of low numbers or allocation to other uses.

Completion date.
2015

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		228,200
Fringe benefits		111,700
Supplies, materials, non-expendable property		75,600

Operations & maintenance		5,400
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	3 laptop computers	6,000
PIT tags	# of tags: 80,000	232,000
Travel		115,700
Indirect costs		146,400
Subcontracts		160,000
Other		
TOTAL		1,081,000

Outyear costs

Outyear costs	**FY2000**	**FY01**	**FY02**	**FY03**
Total budget	1,200,000	1,200,000	1,200,000	1,200,000
O&M as % of total	0.5	0.5	0.5	0.5

Section 6. Abstract

f. How results will be monitored and evaluated.

The goal of this study is to provide up-to-date, precise estimates of survival of juvenile salmonids migrating through reservoirs, dams, and free-flowing reaches of the Snake and Columbia Rivers. This information is critical in determining which restoration strategies to use to recover depressed stocks.

To accomplish this goal, we will continue to PIT tag yearling chinook salmon and steelhead at Lower Granite Dam as needed to estimate their survival through the hydropower system. When possible, we will utilize fish PIT-tagged in other studies to reduce tagging needed specifically for our study. We will also continue to PIT tag hatchery subyearling fall chinook salmon for release above Lower Granite Dam to estimate their survival. As the PIT-tag system expands on the Columbia River, we will estimate survival over longer reaches of the hydropower system. Using combination radio/PIT tags, we will determine where losses and delay occur for yearling chinook salmon between the hatchery and the head of Lower Granite Reservoir.

We will also explore the relationships among survival, travel time, environmental variables, and dam operations using the expanding data base generated by this study.

Section 7. Project description

a. Technical and/or scientific background.

Hydrosystem mortality estimates in the 1970s (Raymond 1979, Sims and Ossiander 1981) were derived from studies in a river system that differs considerably from that which exists today (Williams and Matthews 1995). The magnitude, locations, and causes of smolt mortality under present passage conditions must be quantified accurately and precisely. Until this is accomplished, our ability to develop corrective

measures and to assess their effects will be limited. ***Studies to estimate survival of juvenile salmonids migrating through the Snake and Columbia River hydrosystem, and the relationship between survival and environmental conditions, are called for in the NMFS 1994 Biological Opinion, NPPC 1994 Fish and Wildlife Plan, and the NMFS Recovery Plan.***

Recent advances in fish-marking technologies (e.g., Passive Integrated Transponder (PIT) tags, "balloon tags," and miniature radiotransmitter tags) and statistical methodology have provided new approaches for the design and analysis of smolt passage studies. Burnham et al. (1987) proposed models for paired release-recapture data [hereafter referred to as Paired-Release (PR) Models] that appeared appropriate for the estimation of survival through hydroelectric projects via turbines, bypasses, or spill. Valid estimation of survival in longer stretches of river (reservoirs and free-flowing river sections) has been more problematic, because the PR Model assumption of mixing and simultaneous downstream movement of reference and test groups is difficult to satisfy when release locations are farther apart.

Hoffmann and Skalski (in Dauble et al. 1993) demonstrated how release-recapture models proposed by Cormack (1964), Jolly (1965), and Seber (1965) may be applied to single release groups of PIT-tagged fish. The Cormack model is hereafter referred to as the Single-Release (SR) Model. However, Hoffmann and Skalski also showed that survival estimates based on the SR Model were biased when mortality occurred in juvenile bypass systems after the fish were detected (i.e., between detection and remixing with non-bypassed fish). The Modified Single-Release (MSR) Model (Dauble et al. 1993) was proposed to correct for this bias. Satisfying the assumptions of the SR and MSR models appeared easier than for those of the PR Model, thus making quantitative measures of precision possible.

Beginning in 1993, the National Marine Fisheries Service (NMFS) and the University of Washington (UW) conducted research to determine survival and travel-time characteristics of wild and hatchery-reared spring/summer chinook salmon and hatchery steelhead migrating through Snake River dams and reservoirs (Iwamoto et al. 1994; Muir et al. 1995, 1996; Smith et al. 1997). The goals of this research program were to 1) field test and evaluate the Single-Release, Modified Single-Release, and Paired-Release Models for the estimation of reach and project survival, 2) identify operational and logistical constraints to their execution, 3) determine their usefulness in providing estimates of reach and project survival with known precision, and 4) obtain baseline survival and travel time estimates. In 1995, a pilot study was initiated using hatchery-reared subyearling fall chinook salmon to estimate their survival through these same reaches. To a large extent, the objectives, techniques, and analyses have been the same for all species.

The research from 1993 through 1997 has shown that the field techniques to collect and PIT tag fish, and statistical methodologies to analyze multiple downstream detections of PIT-tagged fish, are sound and result in accurate and precise survival and travel-time estimates. Estimates of survival for yearling chinook salmon and steelhead

have generally been higher than expected before the beginning of the study, averaging about 90% or greater per reservoir/dam combination each year. Survival estimates for PIT-tagged smolts released from hatcheries upstream from Lower Granite Dam were also calculated each year. Survival probability estimates to Lower Granite Dam tailrace for hatchery releases were lower than for our releases at the head of Lower Granite Reservoir and were generally inversely proportional to migration distance. Estimates of survival for hatchery subyearling fall chinook salmon have been much lower **than for spring/summer chinook salmon migrants, both from their release above Lower Granite Reservoir to Lower Granite Dam, and in the reaches downstream between dams.**

b. Proposal objectives.

Objective 1. Provide annual estimates of survival for spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs.

Annual estimates of survival will be provided to the region to help determine the effectiveness of management strategies used to improve survival for juvenile salmonids migrating through the Snake and Columbia Rivers. Estimates will be provided first in the form of a memorandum followed by an in-depth annual report.

Objective 2. Estimate survival through longer reaches of the Snake and Columbia Rivers.

As PIT-tag interrogation systems come on line at dams farther downstream, survival will be estimated through longer reaches of the Snake and Columbia Rivers. Additional interrogation sites downstream must be evaluated to determine the extent of post-detection bypass mortality, if any. This information will be provided in the form of a memorandum followed by an in-depth annual report.

Objective 3. Partition mortality between release at hatcheries and the head of Lower Granite Reservoir.

Comparison of survival estimates for releases from Snake River Basin hatcheries, trap sites, and fish purse-seined and released at the head of Lower Granite Reservoir indicate a great deal of smolt mortality occurs upstream from the hydropower system. Partitioning where and when this mortality occurs might allow us to determine the causes of mortality so corrective action could be taken to improve survival. This information will be provided in the form of a memorandum followed by an in-depth annual report.

Objective 4. Estimate survival for subyearling fall chinook salmon migrating through the Snake River.

Information on survival and travel time for subyearling fall chinook salmon migrating through the Snake River is needed to make management decisions to maximize their survival. Because too few natural fish are available to make reliable estimates of survival each year, hatchery subyearlings are used as surrogates and their performance

compared to natural migrants. This information will be provided in the form of a memorandum followed by an in-depth annual report.

Objective 5. Explore relationships between smolt survival in the Columbia River Basin and flow, travel time, and dam operations using a long-term data set.

Under this objective, we will test the following hypothesis:

Ho1: The effects of environmental conditions (e.g., flow, water temperature, turbidity) have no influence on smolt survival through the Snake River.
If rejected, alternate hypotheses are that some of these factors do influence smolt survival.

Ho2: The effects of project operations (e.g., increased spill, reservoir drawdown) have no influence on smolt survival through the Snake River.
If rejected, alternate hypotheses are that some of these factors do influence smolt survival.

Ho3: The effects of project improvements (e.g., installation of surface collectors, extended length screens, changes in turbines and bypass systems to improve survival) have no influence on smolt survival through the Snake River.
If rejected, alternate hypotheses are that some of these factors do influence smolt survival.

This information will be provided in annual reports and/or peer reviewed publications.

c. Rationale and significance to Regional Programs.

This study (Objective 5) addresses needs identified in the 1994 FWP (Juvenile Salmon Migration, Research and Monitoring Section 5.0F) for a better understanding of the relationship between spring and summer flow velocity and survival. The FWP states: "The Council joins with the National Marine Fisheries Service and other regional interests in insisting that these relationships immediately receive the highest priority in the region's research efforts." This study (Objective 4) also addresses Section 5.8A8 which states: "Continue to conduct research on the survival of hatchery, wild, and naturally spawning chinook salmon from headwater production areas to mainstem transport sites to determine the extent of mortality prior to transportation."

The 1995 NMFS Biological Opinion (Section 13f, Reasonable and Prudent Alternatives) states: "The BPA shall evaluate juvenile survival during downstream migration and desired levels of flow augmentation. The NMFS, in cooperation with other agencies and entities, shall formulate long-range survival studies to determine within-year and between-year survivals of smolts migrating through reservoirs and past dams with various flows, spills, and bypass configurations. Studies will relate survival to varying river flows, spills, and dam operations. As an offshoot of the research, studies will be designed to update or confirm relationships of migration rates of fish to flow in the river. Further, where feasible, researchers will determine relationships of fish survival to migrational timing."

Clearly, this study addresses needs outlined in the 1994 NPPC FWP and the NMFS FCRPS Biological Opinion by providing annual estimates of smolt survival and their relationship with environmental conditions and hydrosystem operations. This study has complemented other studies in the basin by estimating survival for PIT-tagged smolts released by other researchers (i.e., transportation evaluation, Idaho PIT tag study, releases from hatcheries and trap sites). Utilizing PIT-tagged fish from these other studies has greatly reduced the numbers of fish needed for our tagging each year.

d. Project history

Results Achieved

During the first year of this study (1993), seven groups of yearling chinook salmon were purse-seined near the head of Lower Granite Reservoir, PIT-tagged, and released to evaluate the suitability of the Snake River PIT-tag interrogation and slide-gate systems and the SR and MSR Models for estimating survival through the Snake River. Additional releases were made at Lower Granite and Little Goose Dams to evaluate post-detection bypass survival (testing a model assumption), turbine survival, and spillway survival (at Little Goose Dam only). The study plan was successfully executed resulting in estimates of survival for yearling chinook salmon from the head of Lower Granite Reservoir to the tailraces of Lower Granite and Little Goose Dams. Estimates of survival for turbine and spillway passage were also obtained as well as estimates of survival for releases of PIT-tagged salmonids from Snake River Basin hatcheries and trap sites.

Results from 1994 and 1995 included survival estimates from the head of Lower Granite Reservoir for yearling chinook salmon purse-seined, PIT-tagged, and released over a greater portion of the migration, survival estimates for purse-seined hatchery steelhead, and survival through an additional reach, from Little Goose Dam to Lower Monumental Dam tailrace. Paired releases were also made at Lower Granite, Little Goose, and Lower Monumental Dams to estimate post-detection bypass and turbine survival. Survival was also estimated for releases of PIT-tagged fish from Snake River Basin hatcheries and trap sites.

During 1995, large numbers of PIT-tagged yearling chinook salmon were released in the tailrace at Lower Granite Dam to evaluate transportation. This permitted estimation of survival through an additional reach, from Lower Monumental Dam tailrace to McNary Dam tailrace (through two dams and reservoirs). We also provided estimates of survival for hatchery subyearling fall chinook salmon migrating through the Snake River in 1995 by transporting PIT-tagged Lyons Ferry Hatchery fish upstream and releasing them.

In 1996, we began efforts to determine where mortality occurs above Lower Granite Reservoir by releasing PIT-tagged yearling chinook salmon captured by beach seine in the free-flowing Snake River above Asotin, Washington. We also provided estimates of survival through each of the downstream reaches to the tailrace of Lower Monumental Dam and, for yearling chinook salmon, to the tailrace of McNary Dam, as

well as estimates of survival for PIT-tagged fish from Snake River Basin hatcheries and trap sites. In our 1996 annual report, we explored relationships between smolt survival through the Snake and Columbia Rivers and flow, travel time, and dam operations using the estimates of survival obtained from 1993 through 1996. We also continued our releases of PIT-tagged Lyons Ferry Hatchery subyearling fall chinook salmon above Lower Granite Dam.

In 1997, we continued efforts to partition where mortality occurs above Lower Granite Reservoir by releasing PIT-tagged/radio-tagged (combination tag) yearling chinook salmon at Lookingglass Hatchery and monitoring their behavior, travel time, and survival downstream to the head of Lower Granite Reservoir. We also provided estimates of survival through each of the downstream reaches to the tailrace of Lower Monumental Dam for hatchery yearling chinook salmon (from the Idaho PIT tag study) and steelhead (PIT-tagged and released at Lower Granite Dam), and continued releases of PIT-tagged Lyons Ferry Hatchery subyearling fall chinook salmon above Lower Granite Dam.

Adaptive Management Implications

The survival estimation methods developed and tested in this study can be used to evaluate various management strategies for the Snake River such as drawdown, flow augmentation, or spill programs by comparing changes in survival within and across years. The paired-release methods can be used to evaluate structural modifications at dams, such as flow deflectors on spillways, surface bypass collectors, extended length screens, and changes in turbine operation.

Project Reports and Technical Papers

Iwamoto, R. N., W. D. Muir, B. P. Sandford, K. W. McIntyre, D. A. Frost, J. G. Williams, S. G. Smith, and J. R. Skalski. 1994. Survival estimates for the passage of juvenile chinook salmon through Snake River dams and reservoirs, 1993. Annual report to Bonneville Power Administration, Portland, OR, Contract DE-AI79-93BP10891, Project 93-29, 140 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Muir, W. D., S. G. Smith, E. E. Hockersmith, S. Achord, R. F. Absolon, P. A. Ocker, B. M. Eppard, T. E. Ruehle, J. G. Williams, R. N. Iwamoto, and J. R. Skalski. 1996. Survival estimates for the passage of yearling chinook salmon and steelhead through Snake River dams and reservoirs, 1995. Annual report to Bonneville Power Administration, Portland, OR, Contract DE-AI79-93BP10891, Project 93-29, and U.S. Army Corps of Engineers, Walla Walla, WA, Project E86940119, 150 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Muir, W. D., S. G. Smith, R. N. Iwamoto, D. J. Kamikawa, K. W. McIntyre, E. E. Hockersmith, B. P. Sandford, P. A. Ocker, T. E. Ruehle, J. G. Williams, and J. R. Skalski. 1995. Survival estimates for the passage of juvenile salmonids through Snake

River dams and reservoirs, 1994. Annual report to Bonneville Power Administration, Portland, OR, Contract DE-AI79-93BP10891, Project 93-29, and U.S. Army Corps of Engineers, Walla Walla, WA, Project E86940119, 187 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Smith, S. G., W. D. Muir, E. E. Hockersmith, S. Achord, M. B. Eppard, T. E. Ruehle, J. G. Williams, and J. R. Skalski. 1998. Survival estimates for the passage of juvenile salmonids through Snake River dams and reservoirs, 1996. Annual report to Bonneville Power Administration, Portland, OR, Contract DE-AI79-93BP10891, Project 93-29. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

Smith, S. G., W. D. Muir, E. E. Hockersmith, M. B. Eppard, and W. P. Connor. 1997. Passage survival of natural and hatchery subyearling fall chinook salmon to Lower Granite, Little Goose, and Lower Monumental Dams, p. 1-65. *In* J. G. Williams and T. C. Bjornn (editors). Fall chinook salmon survival and supplementation studies in the Snake and Lower Snake River Reservoirs, 1995. Annual report to Bonneville Power Administration, Portland, OR, Project 93-029, and U.S. Army Corps of Engineers, Walla Walla, WA. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112-2097.)

e. Methods.

Scope

In 1999, we plan to continue providing reach and project survival estimates through Snake and Columbia River dams and reservoirs throughout the yearling chinook salmon, subyearling chinook salmon, and hatchery steelhead migrations. To reduce the numbers of fish needed for PIT tagging, we will rely on releases of PIT-tagged yearling chinook salmon from hatcheries (Idaho PIT-tag Study and other hatchery studies) and Lower Granite Dam (Transport Evaluation) to estimate survival through the Snake River if those studies are conducted. If they are not, we will collect, PIT tag, and release hatchery steelhead and yearling chinook salmon at Lower Granite Dam. We will evaluate survival through the bypass systems at McNary and John Day Dams to estimate the amount of post-detection bypass mortality (a Single-Release Model assumption) that occurs, and evaluate other passage routes at those dams if needed. We will also continue our efforts using PIT tags and radio telemetry to determine where and when mortality occurs for yearling chinook salmon between release from Snake River Basin hatcheries and arrival at the head of Lower Granite Reservoir. We will also continue releasing PIT-tagged hatchery subyearling fall chinook salmon above Lower Granite Reservoir each year to estimate survival during the summer.

Approach

Approximately 20,000 hatchery steelhead will be collected, tagged, and released at Lower Granite Dam in proportion to their arrival timing. A similar number of hatchery

yearling chinook salmon will also be tagged there if sufficient numbers of smolts are not PIT tagged for other studies in 1999 (Idaho PIT-tag Study or Transport Evaluation Study).

We will evaluate post-detection bypass survival at McNary and John Day Dams during 1999 by making paired releases of hatchery steelhead and hatchery yearling chinook salmon at each dam, with the releases consisting of a bypass release (made in front of the intake screen) and a tailrace release.

To partition yearling chinook salmon mortality from release at the hatchery to Lower Granite Dam, we will release from a Snake River Basin hatchery smolts that have been PIT tagged and radio tagged. Their behavior, travel time, and survival will be monitored during downstream migration using fixed-site and mobile radio tracking.

To estimate survival for subyearling fall chinook salmon, we will PIT tag approximately 29,000 fish at Lyons Ferry Hatchery, transport them to release sites in the free-flowing Snake River (Pittsburg Landing) and the Clearwater River (Big Canyon Creek) and release them after short-term acclimation each week from the end of May until the end of June.

Detailed Methodology

Objective 1. Provide annual estimates of survival for spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs.

Task a. PIT tag and release juvenile salmonids at Lower Granite Dam.

Primary releases will be made in the tailrace at Lower Granite Dam. The collection period will encompass the major portion of the spring migration (6 to 7 weeks) to measure variability through time and to investigate possible relationships between survival and environmental conditions that may vary throughout the season. The number of fish to tag of each species will be determined by numbers being tagged upstream in other studies.

Primary release groups will be composed of a total of approximately 20,000 hatchery-reared steelhead collected at the Lower Granite Dam juvenile collection facility in proportion to their arrival timing at the dam, with a similar number of hatchery yearling chinook salmon also collected if sufficient numbers are not PIT-tagged in other studies. Only hatchery-reared fish, identifiable by the absence of adipose or ventral fins, will be used. Fish-handling methods such as water-to-water transfers and pre-anesthesia will minimize damage and stress to fish during the collection and sorting process. We will hand-inject PIT tags, with pre-established techniques (Iwamoto et al. 1994), using the NMFS transportation marking facility at Lower Granite Dam. Tagging personnel will be supervised by experienced NMFS employees. PIT-tagged fish will be allowed to recover for at least 24 hours. Mortalities will be recorded and removed prior to release. Releases will be made 5 days per week as long as fish are available.

Task b. Estimate detection probabilities and survivals (with standard errors) for above releases.

Detection data for primary release groups will be collected at Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams for fish that are guided into the bypass facilities and interrogated. The majority of detected fish will be returned to the river at all dams. Detection at multiple downstream sites increases the ability to test assumptions of the SR model (e.g., that detected and non-detected fish at a dam have equal probabilities of survival and detection at subsequent detection facilities).

Detection histories for fish of primary release groups will be analyzed to provide estimates and confidence limits for survival probabilities in the following reaches: 1) from Lower Granite Dam tailrace to Little Goose Dam tailrace, 2) from Little Goose Dam tailrace to Lower Monumental Dam tailrace, 3) from Lower Monumental Dam tailrace to McNary Dam tailrace, and 4) from McNary Dam tailrace to John Day Dam tailrace. The SR Model will be used to calculate survival estimates for the primary releases.

A statistical program developed at the University of Washington (Smith et al. 1994) for analyzing release-recapture data will be used to perform all survival analyses. The program, named SURPH, for "Survival with Proportional Hazards," extends the standard Cormack (1964) and Jolly (1965)-Seber (1965) models to allow simultaneous analysis of release-recapture data from multiple release groups.

Task c. Estimate survival probabilities for fish released in other studies in the basin (hatcheries, traps, etc.).

We will provide estimates of survival for release groups of PIT-tagged hatchery yearling chinook salmon and steelhead from hatcheries and traps. We will recommend sample sizes and replicate numbers for releases of PIT-tagged fish from other locations, such as hatcheries or traps.

Objective 2. Estimate survival through longer reaches of the Snake and Columbia Rivers.

Task a. Evaluate post-detection bypass survival at new PIT-tag facilities.

Use of the SR Model to estimate reach survival requires that post-detection bypass mortality at detection sites (dams) in that reach be negligible. If not, the mortality must be quantified and the MSR Model used to estimate survival through that reach. To confidently use the SR Model for estimating survival through the additional reaches made possible by the new PIT-tag facilities at John Day and McNary Dams will require that post-detection bypass survival be evaluated at both sites.

For these evaluations, both hatchery yearling chinook salmon and steelhead will be collected at each dam, PIT-tagged, and released via 7.6-cm flexible hose in front of the intake screens to be guided into the bypass system, or released into the tailrace from tanks mounted on a boat. The tagging procedures will be the same as those described in

Objective 1 with fish held in 2,000-L tanks for 24 hours prior to release. Replicated paired releases of each species at each dam will be made, with the number of fish in each replicate and the number of replicates determined after examining detection probabilities from releases of PIT-tagged fish in 1997.

Post-detection bypass survival will be estimated using the PR Model (Burnham et al. 1987) based on detections of PIT-tagged fish at downstream dams. Comparisons of downstream passage distributions will be made to ensure equal mixing of test and reference groups.

Task b. Determine effects of new PIT-tag interrogation facilities on sample size requirements for PIT tag studies conducted upstream.

New PIT-tag interrogation facilities or increased detection probability at existing downstream sites increase overall PIT-tag detection probability for releases made upstream. This reduces the number of PIT-tagged fish needed to estimate survival while maintaining a particular level of precision, or increases the level of precision for the same release size. This information will be provided to interested researchers.

Objective 3. Partition mortality between release at hatcheries and the head of Lower Granite Reservoir.

Task a. Release PIT-tagged/radio-tagged (combination tag) fish from a Snake River Basin hatchery to determine where mortality and migrational delay occur.

Just prior to release in late March/early April, we will surgically implant a combination radio transmitter/PIT tag into 240 yearling chinook salmon at a hatchery above Lower Granite Dam. An additional 260 yearling chinook salmon will be implanted with a combination dummy radio transmitter/PIT tag to supplement the sample size of "radio-tagged" fish for analysis of the effect of surgically implanted radio transmitters on travel time and survival. Surgical techniques will be similar to those described by Hart and Summerfelt (1975), Mellas and Haynes (1985), Ross (1982), and Moore et al. (1990). Approximately 125 fish will be tagged on each of 4 days. After surgery, radio-tagged fish will be held in a separate area from the general hatchery population for 24 to 48 hours to allow post-surgical recovery and facilitate the removal of post-surgical mortalities.

Radio transmitters for the study will be pulse-coded, will measure 18 mm in length by 7 mm in diameter, and will weigh 1.4 g in air. The combination dummy radio transmitters/PIT tags will be identical to the functional radio transmitters in size and weight. Each functional radio tag will have a unique identification code transmitted with each pulse (base pulse rate 4 seconds). Records of PIT-tag detections at dams will supplement final location data for radio-tagged fish. In addition, if fish are not PIT tagged by the hatchery, 500 hatchery yearling chinook salmon will be PIT tagged to compare their travel time and survival with the radio- tagged fish. All tagged fish will be released with the general hatchery population.

Fixed-site monitors (manufactured by NMFS) will be installed downstream from major tributary confluences or at locations above areas of limited access between the hatchery release location and the head of Lower Granite Reservoir. Spacing between monitors will be less than 60 km. Monitor data will be downloaded once or twice a week, depending on accessibility. Continuous operation of fixed-site monitors will be verified by the presence of a stationary test tag within the monitoring area of each fixed-site receiver. Test tags will transmit for 10 seconds every hour for the duration of the study. The absence of records of test tags will determine periods of time when fixed-site monitors were not operating.

Between fixed-site monitors, mobile tracking by vehicle or boat will be conducted twice a week. Losses to the population will be determined from fish that fail to pass the next fixed-site monitor downstream prior to an individual's transmitter battery expiring and stationary individuals determined during mobile tracking. An attempt to locate all non-migrating fish will be made to determine if they are mortalities. Mortalities will be identified by attempting to disturb radio-tagged fish for which the signal has remained stationary since the last location. An attempt will be made to recover transmitters from all suspected mortalities.

Survival will be estimated as a function of migration distance over the study area, with an estimate generated for each segment of the river as delineated by the monitor locations and/or the locations of observed mortality.

Median travel times for defined sections of the study area will be calculated. Survival from release to Lower Granite, Little Goose, and Lower Monumental Dams will be estimated and compared using the SR Model (Muir et al. 1996) for the radio-and-PIT-tagged group and the PIT-tagged-only group. Chi-square goodness-of-fit tests of detection distributions will be used to test for mixing of the two groups.

Task b. If results from Task a warrant, we will capture, PIT tag, and release smolts from areas where losses or excessive migrational delay occur and estimate survival and travel time.

This task will provide important information by partitioning where and when post-hatchery-release mortality occurs. This will enable future studies to focus efforts on the areas where losses have been identified. Future studies might include releasing PIT-tagged smolts to precisely estimate survival through various reaches, examining the responses of predator populations to hatchery releases, and the effects of management strategies such as flow augmentation and drawdown on migrational behavior and survival. Specific details of how this task would be completed (i.e., location of releases, method of capture, number and size of release groups) would depend on results from 1998 studies.

Objective 4. Estimate survival for subyearling fall chinook salmon migrating through the Snake River.

Task a. Release PIT-tagged Lyons Ferry Hatchery subyearling fall chinook salmon into the free-flowing Snake and Clearwater Rivers.

Hatchery-reared subyearling fall chinook salmon will be released at Pittsburg Landing in the free-flowing Snake River and Big Canyon Creek in the free-flowing Clearwater River. To investigate temporal variability of survival probabilities and travel time, the series of releases will be timed to encompass the major portion of the migration season for wild/natural subyearling fall chinook salmon; approximately a 5- to 6-week period beginning in late May. Fish will be PIT tagged at Lyons Ferry Hatchery, transported to release sites, acclimated in their transport trucks to ambient river water temperature, and released. Size at release of the experimental fish will approximate the size of wild/natural fall chinook salmon present in the river at Pittsburg Landing at the time of release.

Replicate numbers and release sizes are based on the results of the 1995 through 1997 studies and the desired precision. A variety of conditions and parameter values were used to calculate expected precision of the survival estimates and to determine the number of replicate releases and number of fish per release. Over a 6-week period beginning in late May, we plan to release 1,250 fish per week at each release site. For expected survival of 60% from point of release above Lower Granite Reservoir to Lower Granite Dam tailrace, we anticipate that six releases of 1,250 fish each will result in precision of approximately 0.044 (half-width of 95% confidence interval).

A series of paired releases of PIT-tagged hatchery-reared subyearling fall chinook salmon will be made at Lower Granite Dam, with recaptured fish from the separation-by-code system, to evaluate post-detection bypass mortality. The treatment groups will be released into the bypass outfall and the reference groups released in the tailrace just downstream from the bypass outfall site. The number and size of replicates will depend on how many of the fish released upstream are collected in the separation-by-code system each day. Data from pairs of releases will be pooled across days as necessary and analyzed using the PR Model to estimate post-detection mortality.

Task b. Estimate their survival and compare to estimates of survival for wild migrants in this reach.

Data processing, data quality assurance/control, and survival estimation methods will be identical to those for spring/summer chinook salmon and steelhead (see Objective 1). For each release, we will compute point estimates and confidence intervals for survival probabilities through each of the reaches. Travel time statistics will also be computed. The SR Model will be used to estimate survival probabilities for the Pittsburg Landing and Big Canyon Creek releases if there is no significant post-detection bypass mortality, while the MSR Model will be required if significant post-detection bypass mortality is indicated.

Objective 5. Explore relationships between smolt survival through the Snake and Columbia Rivers and flow, travel time, and dam operations using a long-term data set.

<u>Task a</u>. Correlate survival estimates with flow, temperature, travel time, and dam operations for individual years and over multi-years.

We will conduct correlation analysis with the survival estimates obtained each year with estimates of travel time for those fish and their exposure to environmental variables including flow, water temperature, turbidity, and dissolved gas exposure. We will access the environmental data from the internet site located at the University of Washington (DART) and/or the Fish Passage Center. Similar analyses will be performed using the survival estimates and environmental data from multiple years of the study.

f. Facilities and equipment.

This project relies mainly on the PIT-tag interrogation systems at dams (and slide-gates at transport dams) and the PSMFC PTAGIS system to provide data needed for survival analysis. As we begin to use the new PIT-tag frequency, we will need to purchase new PIT-tagging equipment compatible with the new tag. Other equipment (boats, vehicles, tagging supplies, radio-tag monitors, etc.) was purchased in earlier years of this study and will be periodically replaced as needed.

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Section 8. Relationships to other projects

This study complements studies we are conducting at Little Goose Dam (COE Project E86970085) which evaluates survival for yearling chinook salmon and steelhead passing through the turbine, spillway, or the bypass system. By combining estimates of passage route survival (COE study) with our estimates of reach survival and detection probability (BPA 93-029), we are able to estimate overall project survival, reservoir survival, spill efficiency, and spill effectiveness at Little Goose Dam.

Study 93-029 also estimates survival for yearling chinook salmon released at Lower Granite Dam to evaluate transportation (COE Project E8690103). In years the transport study is conducted, we rely on the control fish released at Lower Granite Dam to estimate survival through the hydrosystem instead of tagging our own fish for this purpose.

Personnel from this project frequently provide technical advice on study design and statistical analysis to other researchers conducting PIT-tag studies in the basin.

Section 9. Key personnel

William D. Muir

Fisheries Research Biologist (Principal Investigator).
B.S. (1977) and M.S. (1991) in Biology, Portland State University. National Marine Fisheries Service, Fish Ecology Division (1978 to present). Coordinates the design, conduct, analyses, and report preparation for the study.

Mr. Muir has worked as a Research Fisheries Biologist for the National Marine Fisheries Service for almost 20 years, working primarily on juvenile salmonid behavior and migration throughout the Columbia River Basin. He has participated in juvenile salmonid research in the Columbia River estuary (distribution, movement, food habits, interactions with other species), at Snake and Columbia River Dams (fish guidance studies, bypass evaluations, behavioral and physiological status of smolts and their effects on fish guidance), at hatcheries (homing studies, photoperiod and temperature manipulation studies and their effect on migration and survival), and most recently on reach survival studies. He began using PIT tags in his research in 1988. He is currently the Team Leader for the Migratory Behavior and Survival group of the Fish Passage Program, Fish Ecology Division.

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physiological changes in yearling chinook salmon during hatchery resdidence and downstream migration. Aquaculture 127:69-82.

Steven G. Smith

Statistician
B.S. (1985) in Computer Science, Utah State University. M.S. (1987) in Biostatistics, and Ph.D. (1991) in Quantitative Ecology and Resource Management, University of Washington. National Marine Fisheries Service, Fish Ecology Division (1994 to present). Manages data, performs analyses, writes reports.

Dr. Smith has worked as a Mathematical Statistician for the National Marine Fisheries Service since 1994, during which time his principal responsibility has been management and analysis of PIT-tag data. He was previously a graduate student and then professional staff member at the University of Washington (1987-1994), where he developed statistical models for capture-recapture and computer software (SURPH) to implement them, and helped plan the first two years of the joint NMFS/UW Snake River survival study. Since spring 1995, Dr. Smith has participated in the region's PATH (Plan for Analyzing and Testing Hypotheses) process.

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Section 10. Information/technology transfer

The technical information obtained from this project will be provided to researchers, modelers, and managers through annual reports to BPA, peer-reviewed publications, direct response to requests from PATH participants, and through presentations at public meetings. In addition, more timely reporting of estimates of survival will be provided each year through memoranda to interested parties.